Energy, Power & Interconnect Technologies Division Overview

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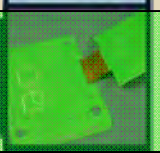
Agenda

- **Introduction**
- **Workforce**
  - Demographics &Expertise
- **Workload Portfolio**
- **Capabilities**
  - Facilities & Equipment
- **Coalition of Partners**
- **Future Direction**
- **Summary**

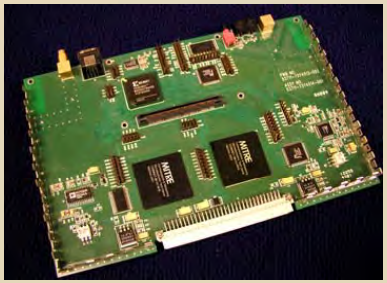
NSWC Crane: Technical Capabilities

- Strategic Systems Hardware 
- Conventional Ammunition 
- Special Operations Hardware 
- Electronic Warfare Systems 
- Radar Components 
- Energy & Power Sources 
- Acoustic Sensors 
- Microwave Technologies 
- Microelectronic Technologies 
- Infrared Countermeasures & Pyrotechnics 
- Defense Security Systems 
- Navy Electronics Depot 
- Electro-Optic Systems 
- Obsolescence Management 

Our Product Expertise

Crane provides cradle to grave power system engineering services for ship, air, land, and space based systems

Power Systems



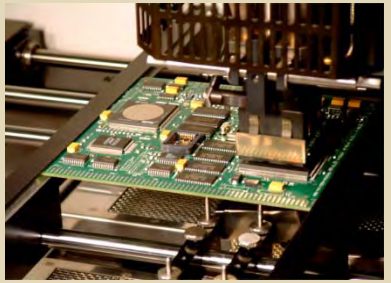
Unique and comprehensive Printed Circuit Board development, manufacturing, test, and evaluation capabilities

Electronic Interconnect Technology

Crane is DoD's largest and most capable battery evaluation facility with a unique abusive test facility and extensive environmental capabilities

High Energy Test Facility

Navy's ***ONLY*** Printed Circuit Board manufacturing facility and one of only two DoD Printed Circuit Board Manufacturing facilities



Electrochemistry Eng Facility

Energy, Power & Interconnect Technologies Division

Vision

THE DoD Authority in Energy, Power Systems & Interconnect Technologies

Mission

Ensure the warfighters have the necessary Power & Interconnect Technology Products and Support to successfully execute their mission

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Workforce Demographics

- **Energy, Power & Interconnect Technologies Partners**
  - **Dedicated Government Workforce**
    - **Consists of 130 Highly Skilled Government Professionals dedicated to 100% to Energy, Power & Interconnect Technologies**
    - **Combined 2000 Years of Experience**
  - **Academic Partners**
    - **Extensive Involvement with Academia for R&D efforts**
  - **Industry Partners**
    - **Heavily involved with Industry Partners across all phases of Life cycle**

Electrochemistry Battery Expertise

Alkaline (Sealed/Vented)	Lithium (Reserve/Active)	Thermal
Aluminum-Oxygen (Air) Cadmium-Oxygen (Air) Carbon-Zinc Mercury-Cadmium Mercury-Zinc Nickel-Zinc Nickel-Iron Nickel-Cadmium Nickel-Hydrogen Nickel-Metal Hydride Silver-Zinc Silver-Cadmium Silver-Hydrogen Silver-Metal Hydride Silver-Iron Zinc-Manganese Dioxide Zinc-Oxygen (Air)	Carbon Monofluoride Copper (II) Oxide Copper Sulfide Iodine Manganese Dioxide Iron Disulfide Oxyhalide Polymer Sulfur Dioxide Sulfuryl Chloride Thionyl Chloride Vanadium Pentoxide Polymer Electrolyte Cobalt Oxide Manganese Oxide	Calcium/Calcium Chromate Calcium/Potassium Di chromate Lithium Iron/Iron Disulfide Lithium Aluminum/Iron Disulfide Lithium Silicon/Iron Disulfide Lithium Silicon/Cobalt Disulfide Magnesium/Vanadium Pentoxide
	Lithium (Rechargeable)	**Lead-Acid**
	Lithium-Ion Lithium-Polymer Lithium Alloy	Absorbed Electrolyte Antimony Grid Calcium Grid Gel Electrolyte Flooded Electrolyte Pure Lead Grid
		Other
		PEM Fuel Cell Seawater Ammonium Sodium-Sulfur

Capacity Ranges: 0.03 to 10,000 Ah

Workforce Expertise

- **Engineering Assignments**
  - **PMS NSW Engineering Agent for Battery Systems**
  - **Technical Direction Agent (TDA)**
    - **Standard Missile Batteries (NAVSEA)**
  - **Special Warfare Batteries (WARCOM)**
    - **AN/WSN-2, 2A & 5 System Batteries**
  - **In-Service Engineering Agent (ISEA)**
    - **Submarine and Submersible Main Storage Batteries (NAVSEA)**
    - **Seal Delivery Vehicle Automated Battery Charger (WARCOM)**
    - **Advanced Seal Delivery System Battery**
  - **Qualifying Agent**
    - **Trident, Seawolf & Virginia Class Submarine Batteries (NAVSEA)**
  - **Acquisition Agent**
    - **Submarine and Submersible Main Storage Batteries (NAVSEA)**
  - **Lead Maintenance Technology Center**
    - **Electrochemical Systems (NAVAIR)**

Total of 23 Engineering Agent Assignments

Workforce Expertise

- **Engineering Development**
  - Assist transition of early TRL concepts to in-service
  - Champion funding and identify leverage opportunities
- **Manufacturing Technology**
  - Assist manufacturers with process upgrades, updates
  - Troubleshoot, assess root cause, corrective actions
- **Test & Evaluation**
  - Lithium battery safety testing
  - Design Verification, Qualification, LAT, Manufacturing validation, Stockpile Reliability, Failure Analysis, Disposal
  - Degradation analysis
- **Acquisition**
- **In-service Engineering**

- **Energy & Power Sources Connectivity**
  - Power Sources Conference
  - Aircraft Battery Fleet Support Team (NAVAIR)
  - BATTNET
  - Cooperative Program in Electrochemical Power Systems with Canada Dept of National Defense
  - JDMTP Technical Working Group
  - Joint Service Power Expo
  - Joint Standards Board
  - Lithium Battery Safety Certification (NAVSEA)
  - Naval Energetic Enterprise
  - NATO Power Sources
  - Submarine Main Storage Battery Committee Co-Chair
  - Other power community involvement (eg professional societies, symposia, conferences)

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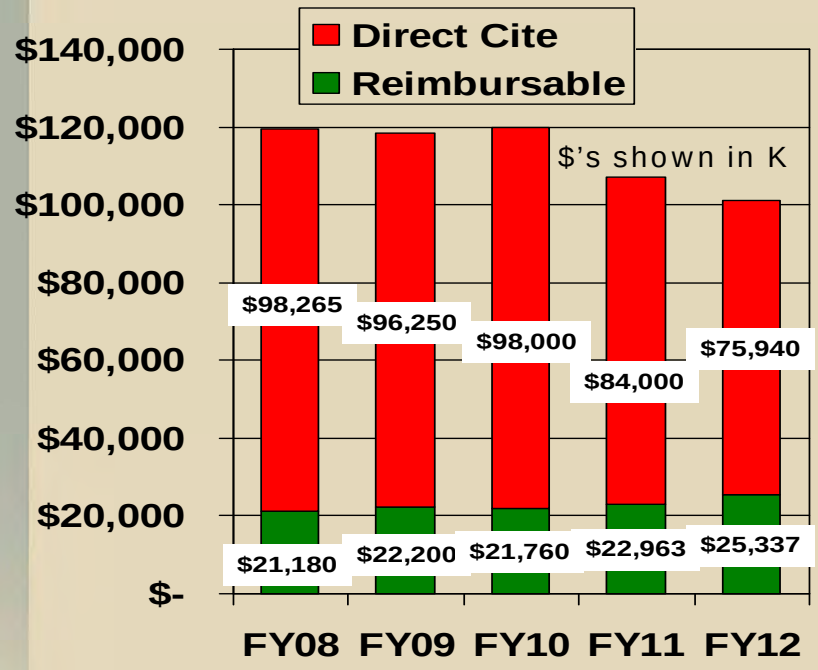
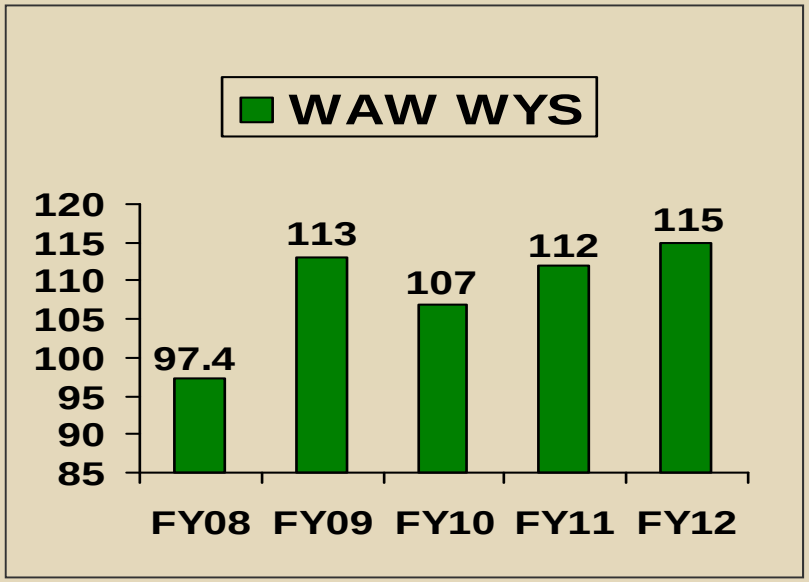
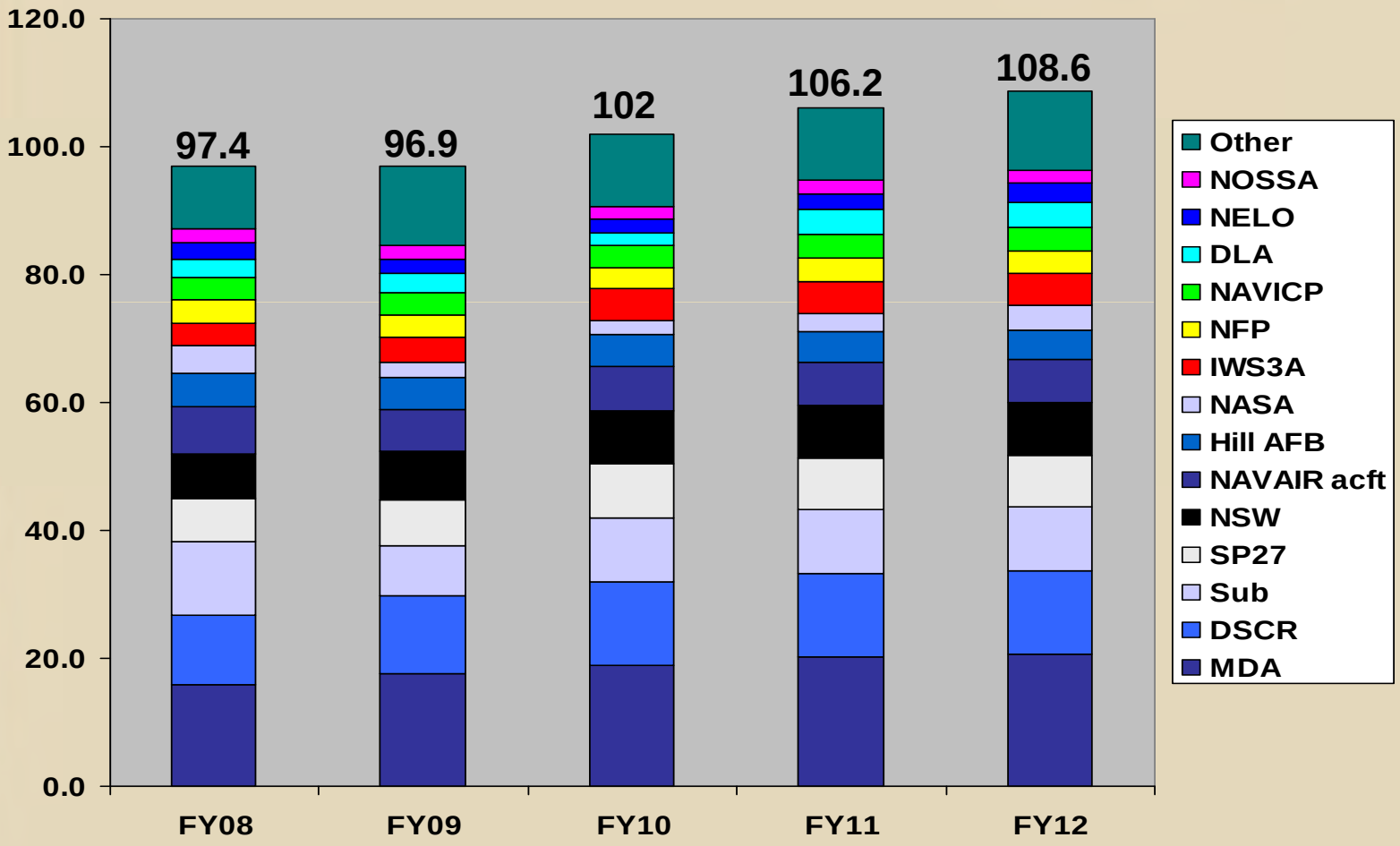
CR06: Energy & Power Sources Portfolio





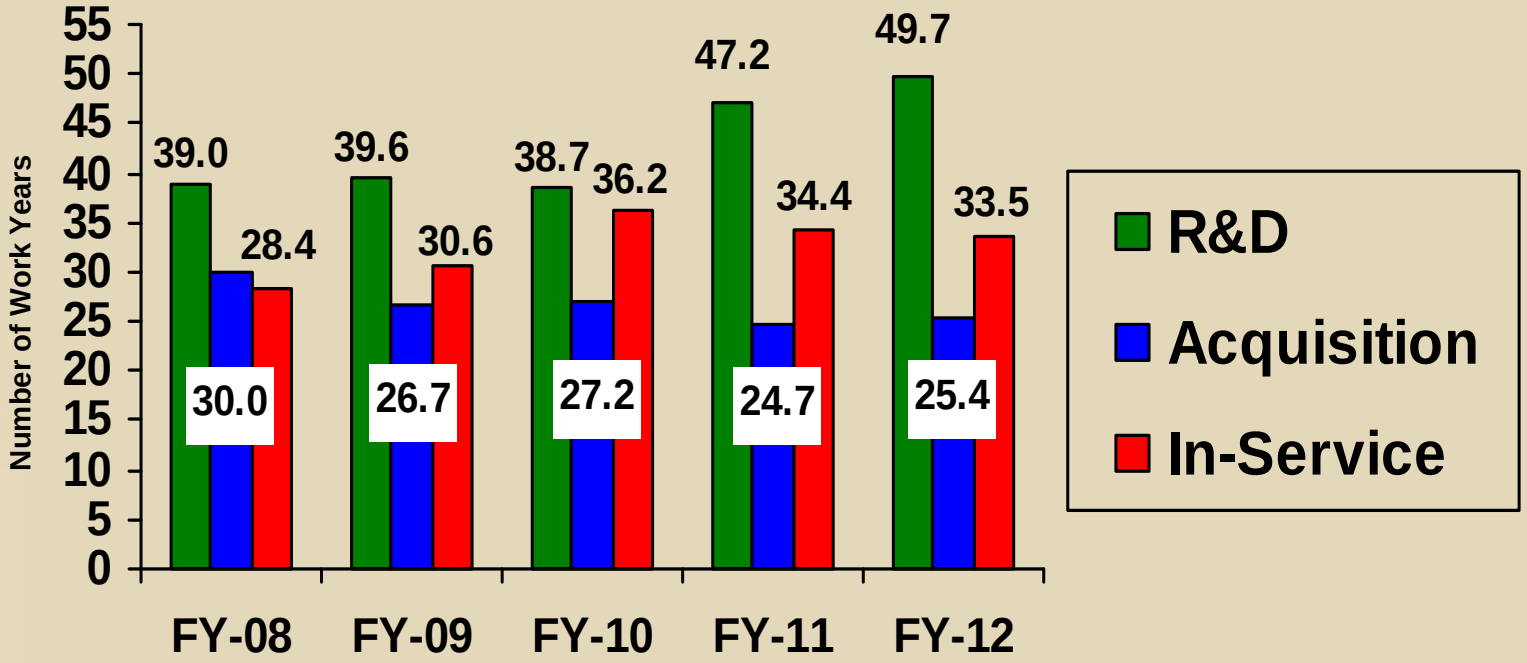
CR06 Funding & Work Years

CR06: Energy & Power Sources Portfolio



CR06 Work Years by Customer

CR06: Energy & Power Sources Portfolio



CR06 Work Years By LCC

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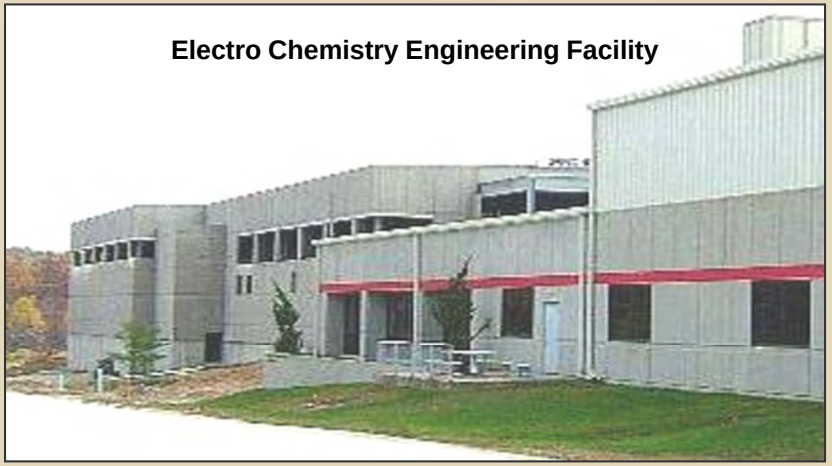
Capabilities
Facilities/Equipment

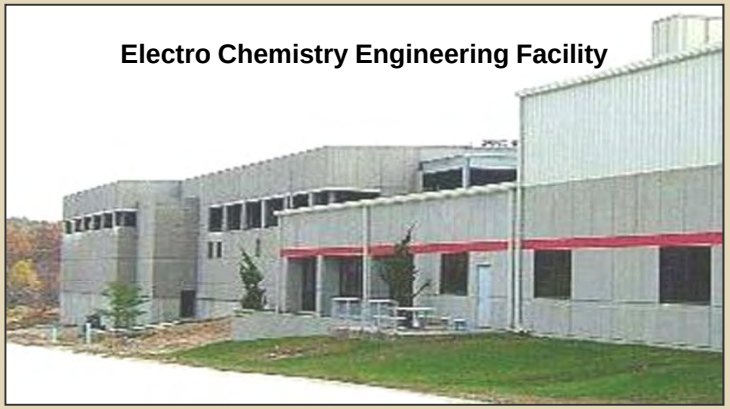


- **DoD's Largest Collection of Resources Dedicated to Electrochemical Power Sources**
  - **Facilities support Technology Development, Acquisition Engineering, Production Engineering, Test and Evaluation, Safety Certification Assessments, and In-Service Engineering**
  - **Facilities meet Government & Industry Standards**

Excess of 100K ft² and $50M of Full Spectrum Electrochemical Power Systems Facility

Capabilities
Facilities/Equipment

- **The Electrochemistry Engineering Facility is a state-of-the-art building for evaluation of battery technology for subsurface to aerospace applications**
  - **Laboratories**
    - **Dissection**
    - **Prototyping**
    - **Fabrication**
    - **Fuel Cell**
    - **Power Supply**
    - **Small Battery**
    - **Aircraft**
    - **Submarine**
    - **Aerospace**
    - **SPECWAR**
    - **Missile**
    - **EMI**
  - **Environmental**
    - **Two +20000lbf Vibration Systems**
    - **600RPM / 300G Centrifuge**
    - **10,000 RPM Spin Tester**
    - **+130000 ft / -500 ft Altitude/Pressure Chamber**
    - **Three Temperature Altitude Chambers**
    - **Salt Fog Chamber**
    - **40 Temperature and Temp/Humidity Chambers**
    - **Dry Room (3% RH)**
    - **Asset Tem Control & Conditioning Rooms**



Capabilities
Facilities/Equipment

- **The High Energy Test and Evaluation Facility is a state-of-the-art building for evaluation high energy electrochemical power sources**
  - **Ten Containment Test Cells**
    - **Eight rated five pounds TNT equivalent explosive capable**
    - **Two rated ten pounds TNT equivalent explosive capable**
    - **Nominal Test Cell Size 15 ft X 20 ft**
  - **Video/Sound and High Speed Video Capable**
  - **Total Containment of Reactions**
    - **Integrated Ventilation System**
  - **Environment Treatment and Disposal of all Hazardous By Products**
  - **Environmental**
    - **45,000lbf vibration system**
    - **600RPM/300g centrifuge**
    - **+300000ft altitude/temperature chamber**
    - **3000g/100lbs./12ft. Drop shock**
    - **+20 temperature and temperature/humidity chambers**

High Energy Test & Evaluation Facility

Capabilities
Facilities/Equipment

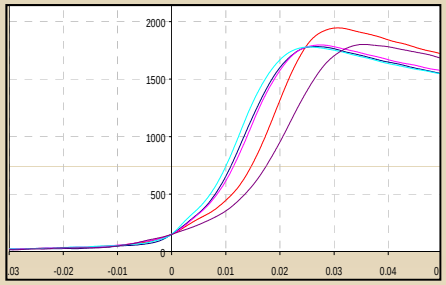
- **Failure Analysis Laboratory**
  - Military and Commercial Product F/A and construction evaluation
  - State of the art analysis instrumentation/equipment
  - Key Equipment: SEMs, Focused Ion Beam Analyzer, Emission Microscope, C/T Scan, Real-Time X-Ray, Acoustic Microscope, Automated Probe Station & Laser
- **Materials Analysis Laboratory**
  - Electron-Optics & Materials Analysis Instruments for Elemental Analysis
    - Secondary Ion Mass Spectrometer
    - Scanning Auger
    - Electron Probe
  - Identification of particulates, contaminants, epoxies, polymers, and organic materials
  - Key Equipment: FTIR, RGA, X-Ray Diffraction, GC/MS
- **Dedicated FA / MA Expertise**
  - Engineers & Scientists (16)
  - Chemists & Materials Engineers (10) – Three PhDs
  - Technicians (12)
  - Average over 20 years of experience

Capabilities
Facilities/Equipment

Materials Analysis Laboratory

- ISO-9001 certified analytical laboratory
- 10,000 ft^2 chemical, thermal, and microscopic laboratory
  - 1 lb explosive limit
- 2500 ft^2 heat flow calorimetry laboratory
  - 50 lb explosive limit
- 1000 ft^2 metallurgical laboratory
  - 10 lb explosive limit
- 1000 ft^2 mechanical properties laboratory
  - 500 lb explosive limit
- Six explosive storage magazines (SRC-I and SRC-II)
  - ranging from 10 lb to 165,000 lb capacity

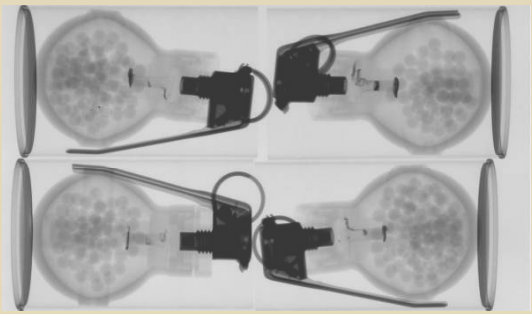
- Failure Analysis
- Material Identification
- Material selection/source identification
- Material compatibility
- Hazard classification
- Environmental compliance testing
- Shelf life determination/extension
- Qualification testing
- Product improvement initiatives



Capabilities
Facilities/Equipment

Nondestructive Test Laboratory

- ISO-9001 certified NDT laboratory
- Three conventional radiographic test bays (160 KeV to 450 KeV)
  - Rated for NEQ of 75 lb 1.1
- One 2000 ft² high energy radiographic test bay
  - Rated for NEW of 2000 lb 1.1 (10 MeV Linear Accelerator)
  - Penetrates over 15 inches of steel
  - Designed to accommodate tractor trailer inspection
- 2000 ft² NDT laboratory space to accommodate UT, ET, PT, and MT testing methods
  - NEW of 1000 lb 1.1



- Conventional and High Energy Radiography
- Laminographic Test System
- Computerized Axial Tomography
- Digital Radiography Imaging systems
- Reconfigurable cabinet x-ray systems
- Ultrasonic inspection
- Eddy current testing
- Penetrant testing
- Magnetic Particle Testing

Capabilities
Facilities/Equipment

Ordnance Test Area

- Encompasses 88 acres
- 5 lb NEW (Class 1.1) (Self-Imposed, 20 lb NEW with restrictions)
- 4 operating and 2 support buildings
- Army Surveillance Function Test Range
- Baseline Environmental Assessment
- Air Quality Modeling Assessment

Ordnance Tested

- Hand Held
- Hand Tossed
- Pistol/Projector Fired
- Countermeasures
- Target Illuminating
- Target Screening
- Demolition Materials
- Special Purpose Munitions

Capabilities
Facilities/Equipment

Environmental Services

Climatic Testing

- Temperature / Shock
- Temperature / Humidity
- Temperature Cycle & Storage
- Altitude
- Salt Fog
- Icing
- Drip


SALT FOG CHAMBER


ENVIRONMENTAL CONDITIONING CHAMBERS

Dynamic Testing

- Vibration
  - Sinusoidal
  - Random
  - Mixed Mode
- Shock
  - MIL-S-901 Shipboard
  - Shock Response Spectrum
  - High Impact
  - Classical
  - Jolt & Jumble


TRANSPORTATION VIBRATION


MEDIUM WEIGHT HIGH IMPACT SHOCK


LIGHT WEIGHT SHIPBOARD SHOCK

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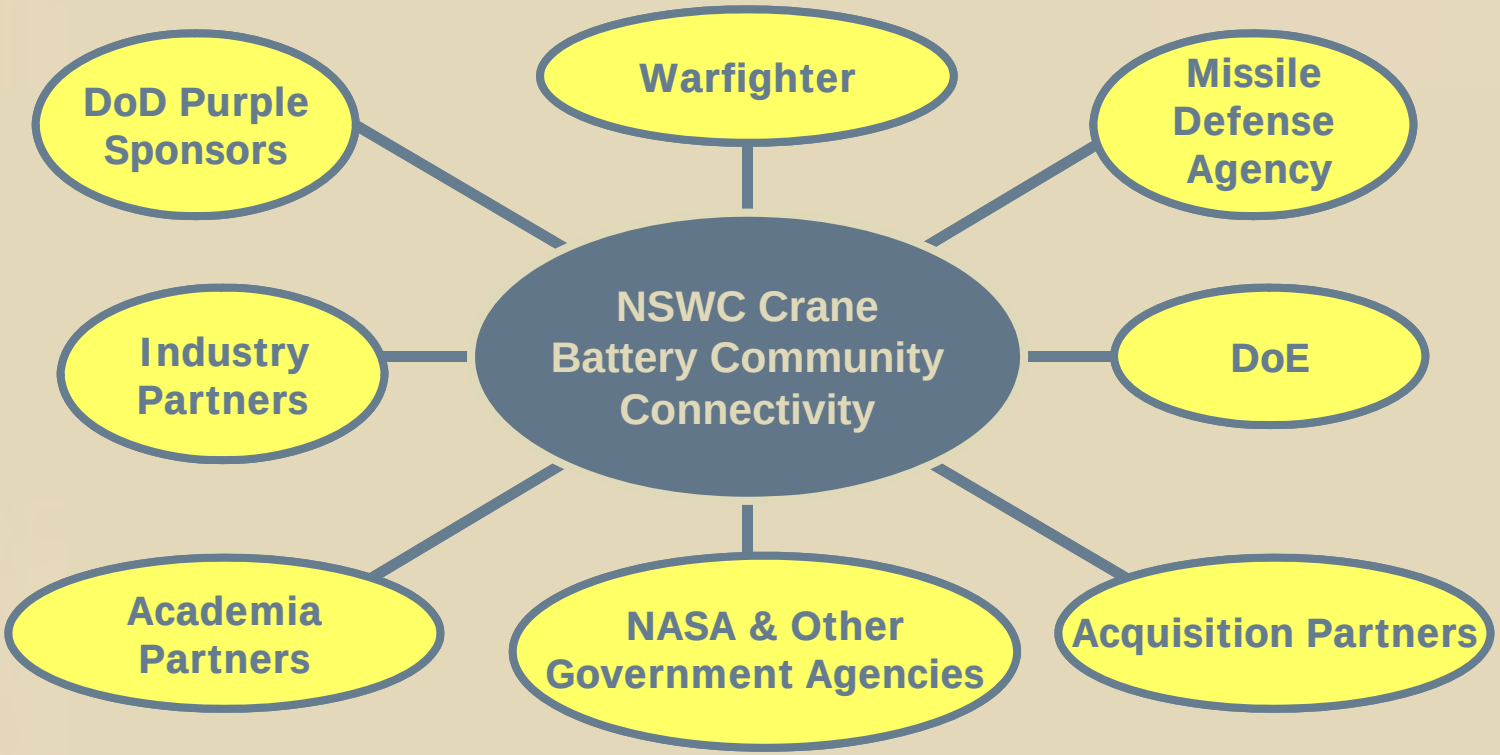
Coalition of Energy & Power Partners



Crane Architects Government, Industry & Academia Partnerships to Best Achieve Successful Technology Transitions for the Warfighter

Coalition of Power Sources Partners

TOGETHER WE SUPPORT THE WARFIGHTER

- **Small Business Research Initiative**
  - **$5.8M in FY09**
- **Service Support Contracts**
  - **$18.0M in FY09**
- **Acquisition of Supplies and Hardware**
  - **$22.5M in FY09**
- **Technology Development**
  - **$13.7M in FY09**

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Energy & Power Technology Initiative (EPTI)

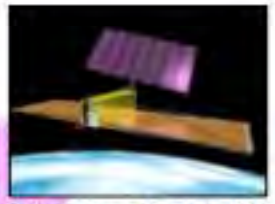
Power Technologies ...Pervasive & Enabling

Technology Taxonomies

- Power Generation / Energy Conversion
- Electromechanical Conversion
- Energy Storage
- Thermal Transport and Control
- Power Control and Distribution


Electric Warship


More Electric Aircraft


Advanced Satellites

Power Needs

FY02 FY12


Warfighter


UAV


UUV

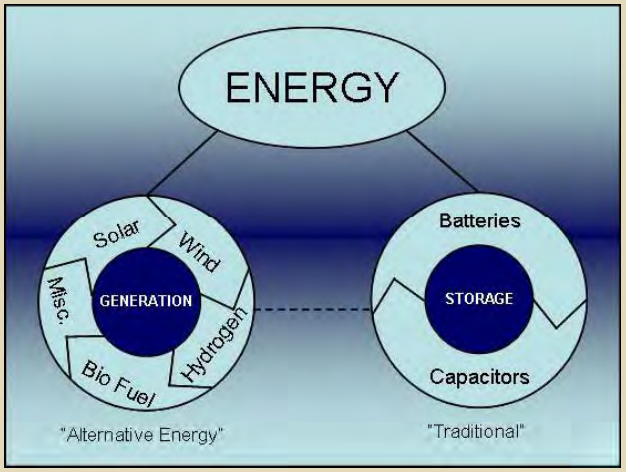

UGV


Hybrid / Electric Combat Vehicle

Future power requirements driving technology development

DoD Energy & Power
Future Direction

- **Power Sources**
  - **Mission Requirements Demand Higher Energy Densities**
  - **Emphasis on Safety**
    - **Cell, Module & Battery Design**
    - **System Packaging**
    - **Battery Management System Design**
    - **Maintenance and Inspection Procedures**
    - **Operational Procedures**
    - **Platform Level Hazard Analysis**
  - **Increased System Level T&E**
  - **Tech Design Specs for Acquisition**
- **Energy**
  - **Energy Storage**
  - **Energy Generation**



Alternative Energy Engagement: The Landscape…

- **Department of Defense (DoD) is world's largest consumer of energy**
- **Alternative Energy (AE) is one of the most visible initiatives within America**
- **AE risks and benefits are unknown within DoD**
  - **What are the AE technologies?**
  - **What are the associated maturity levels?**
  - **What is the manufacturability?**
  - **What is the efficiency and usability?**
  - **What is the economic impact of them?**
- **What are the solutions as systems and how are current logistics and operational scenarios affected?**
- **What are the notional products for R&D, Acquisition and In-Service?**

Alternative Energy Engagement: The Opportunity…

- **Establish a DoD Energy Center of Excellence**

- **Required Credentials**
  - **DoD Laboratory**
    - **Chartered responsibility area in Energy**
    - **R&D and T&E Emphasis**
    - **Technology Leverage**
    - **Collaboration and Partnerships**
  - **Close coordination with DoE**
    - **"DoD seeking partnership where DoE focuses on fundamental energy research, while DoD concentrates on development work using its testing facilities to advance new technologies beyond the laboratory stage."**
      - **Mr. Ashton Carter – OSD AT&L – Inside Defense, 27 May 2009**

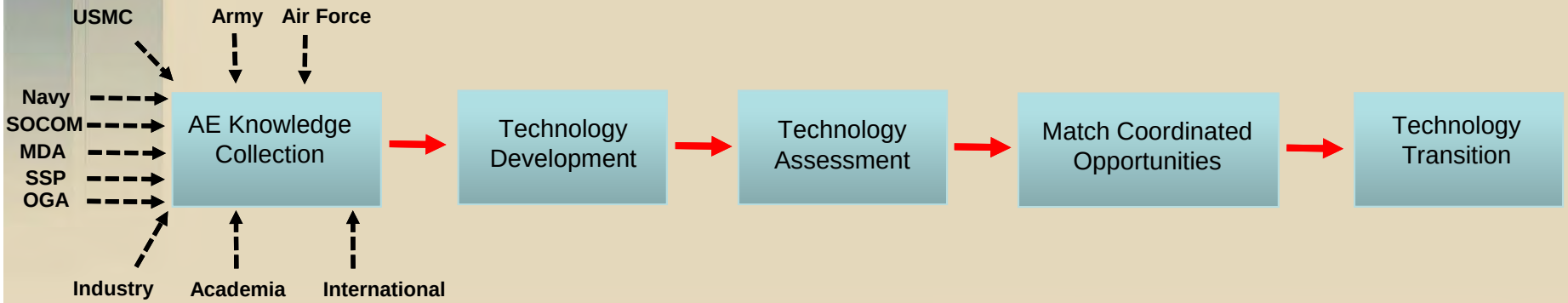
DoD Energy Center: Why NSWC Crane…

- ✓ **DoD Laboratory**
  - ✓ **Chartered responsibility area in Energy**
  - ✓ **R&D and T&E Emphasis**
  - ✓ **Technology Leverage**
  - ✓ **Collaboration and Partnerships**

- **NSWC Crane**
  - **NAVSEA Technical Capability (Cr-06) for Energy & Power Source engineering, test & evaluation, and sustainment workload.**
  - **DoD's largest collection of resources dedicated to Energy & Power Sources**
    - **Annual TOA ~ $125M**
    - **Over 150 highly skilled technical professionals**
    - **Facilities and equipment investments > $100M**
  - **Specializing in providing premier R&D and T&E support for the Warfighter**
  - **Intentional emphasis on collaboration and partnerships**

Alternative Energy Engagement: The Vision...

- **To provide the best possible energy solutions to the Warfighter and other customers**
- **Establish AE Knowledge Center**
  - **Collect and analyze ongoing national and international technology development, studies, and analysis of AE technology**
  - **Particular emphasis on AE technology development, assessment and transition**
- **Success is AE technology transition and deployment in support of Warfighter requirements**



Alternative Energy Engagement: The Approach...

- **NSWC Crane executing intentional efforts to lead, particularly in energy storage**
- **Collaboration and coordination across multiple DoD stakeholders, academic and industry partners strategic imperative**
- **Success is AE technology transition and deployment in support of Warfighter requirements**

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Energy, Power & Interconnect Technologies Summary

- **We are DoD's largest collection of Electro-Chemical Systems resources (Personnel, Facilities & Equipment)**
- **We serve as the Centerpiece of a rich, diversified Coalition of Partners providing broad and extensive Power Sources capability**
- **We provide unique and comprehensive circuit board development, manufacturing and test & evaluation capabilities**
- **We are highly efficient and cost effective**
- **We practice Continuous Improvement every day in support of the Warfighter**